

# Perioperative Management of the Patient with Diabetes

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Diabetes mellitus is a common disease affecting 2–4% of the population. The prevalence of diabetes is predicted to double in the next decade due to increasing obesity. Many people in the community have unrecognized diabetes and it is not unusual for diabetes to be found incidentally when presenting with another illness. The World Health Organization (WHO) has recently revised the diagnostic criteria for diabetes (Figure 1). Surgery in people with diabetes is very common. Estimates suggest that 50% of patients with diabetes will undergo surgery at some time in their lives. Diabetes is a major risk factor for postoperative wound infections, but meticulous control substantially reduces this risk. Aggressive blood sugar normalization can improve outcome in critical illness.

The main aims during surgery for the person with diabetes must be safety and simplicity of care whilst achieving good blood glucose control. Insulin requirement generally increases in the perioperative period, so most patients with diabetes will require adjustments to their treatment whilst in hospital. A reasonable target would be to maintain plasma glucose between 5 and 7 mmol/l. In the perioperative period, it is important to avoid hypoglycaemia, as it may be masked by or attributed to reduced conscious level after anaesthesia or opioid analgesia.

## Pathophysiology

An understanding of the pathophysiology of diabetes and the basic principles of glucose metabolism is fundamental to good diabetes care.

## Glucose metabolism

Glucose is the primary substrate used as an energy source. A normal plasma glucose level is maintained at 4–7 mmol/l by pancreatic and hepatic interaction. Plasma glucose levels are continuously monitored by the pancreatic beta cells and insulin

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### Recognizing undiagnosed diabetes

#### 1 Be suspicious in the following situations

- Wound infections which are slow to heal
- Recurrent fungal infections
- History of thirst or polyuria and nocturia or weight loss
- Patients with peripheral vascular disease, hypertension or ischaemic heart disease

#### 2 Check random plasma glucose on patients over the age of 40, with signs of infection, or undergoing major surgery at pre-admission assessment

#### 3 If plasma glucose $\geq 8$ mmol/l, organize further investigations. In the presence of symptoms, the following are diagnostic of diabetes

- Fasting plasma glucose  $\geq 7$  mmol/l, or
- Random plasma glucose  $\geq 11.1$  mmol/l

**NB:** A fasting glucose  $< 7$  mmol/l does not exclude diabetes. If clinical suspicion is high but the initial test is not diagnostic, arrange for an oral glucose tolerance test.

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secreted in response to a rising plasma glucose concentration. Conversely, a falling glucose level leads to inhibition of insulin secretion and secretion of glucagon by the pancreas. The liver's physiological response to low circulating insulin levels is gluconeogenesis: production of glucose by glycogen breakdown. Therefore in diabetes, plasma glucose levels can rise even when the patient is fasting due to the absolute or relative insulin deficiency.

Insulin is required to promote glucose uptake by cells. In people with diabetes, hyperglycaemia during surgery is quite common due to release of the stress hormones – catecholamines and corticosteroids – which antagonize insulin action. There is a relative deficiency of insulin, which, if not compensated, may lead to a catabolic state. Breakdown of body fat results in the production of ketone bodies, which can result in acidosis due to the dissociation and release of hydrogen ions. The important effects of hyperglycaemia in the perioperative period are electrolyte abnormalities and dehydration resulting from the osmotic diuresis and postoperative infection.

### Types of diabetes and their normal treatments

There are two main types of diabetes: type 1, which was previously known as insulin-dependent diabetes, and type 2, which was previously known as non-insulin-dependent diabetes. Type 1 diabetes most frequently presents in the first three decades of life and is caused by autoimmune destruction of the beta cells in the islets of Langerhans in the pancreas. People with type 1 diabetes are truly insulin dependent and will develop keto-acidosis if insulin is withdrawn. There is a wide range of insulin preparations available and administration is frequently by pen injection devices. Many patients are treated by twice-daily premixed (short- and long-acting)

insulin injections. Those patients wishing to maintain flexibility and control over their diabetes opt for intensive multiple insulin injections using short-acting insulin analogues before meals and long-acting isophane insulin once or twice per day. In the last few years, subcutaneous insulin infusion pumps have gained wider use, especially in North America.

Type 2 diabetes presents later in life than type 1. The cases are multifactorial and have not yet been fully elucidated, but obesity is the strongest association. Insulin production is decreased and the patient exhibits insulin resistance.

People with type 2 diabetes maintain some endogenous insulin production and do not generally develop keto-acidosis but will still become hyperglycaemic. Approximately 30–40% of people with type 2 diabetes are treated with insulin, oral hypoglycaemic agents alone having failed to control their plasma glucose levels adequately.

There are several different types of oral hypoglycaemic agents in use now.

- Metformin is a biguanide and commonly used to treat obese patients. When used alone, it does not cause significant hypoglycaemia. Its therapeutic action is rapid so withholding a few doses whilst the patient is fasting generally does not cause any problem with glycaemic control when it is re-introduced.
- Sulphonylureas are very widely used. When these tablets are withheld for more than 24 hours, it usually takes several days to re-establish glycaemic control, particularly with the longer-acting agents such as glibenclamide and gliclazide. Temporary use of insulin is often required to manage the transition period.
- Acarbose inhibits starch and sucrose digestion. Diarrhoea and flatulence are well-recognized side-effects and so its re-introduction following bowel surgery may need to be delayed.
- Rosiglitazone and pioglitazone are new oral anti-diabetic drugs that are used to treat type 2 diabetes mellitus in patients who cannot achieve good glycaemic control with metformin or a sulphonylurea. They belong to a new class of drugs called glitazones or thiazolidinediones which act at a nuclear receptor called PPAR $\gamma$  to increase sensitivity to circulating insulin. They take several weeks to be fully effective so withdrawal of treatment over a few days may lead to deterioration in glycaemic control that takes a considerable period to improve on reintroduction.

Managing both type 1 and 2 diabetes is complex and it is sensible to involve the diabetes team in the care of patients with diabetes who are undergoing major surgery.

### Principles of management

Admission to hospital is stressful for most people and this results in increased corticosteroid production. The changes in daily routine, exercise and food patterns are likely to have a major impact on the control of plasma glucose levels in people with diabetes. This in turn frequently causes further anxiety, which can often aggravate the problem. Finally, diabetes is a good barometer of general well-being, so raised plasma glucose levels may be the first indicator of a problem such as occult infection.

### Preoperative planning

- Good preoperative metabolic control is imperative. Check HbA1c (Figure 2) in the pre-admission clinic. Liaise with the Diabetes Nurse Specialist or diabetic team if glycaemic control needs to be improved prior to surgery.
- Ensure patient is first on the list. Exceptions are:
  - emergency cases
  - patients with dirty wounds
  - if there is more than one diabetic patient on the list.
- Identify diabetic patients and make the anaesthetists aware of them.
- Discuss with patients how their diabetes will be managed.

### Intra-operative period

- Monitor capillary glucose 2–4-hourly.
- Avoid hypoglycaemia, as anaesthetic agents and opioids may mask the symptoms
- Aim for a blood glucose of 5–7 mmol/l.

### Postoperative period

- 4-hourly monitoring of capillary glucose is required after major surgery in which the patient will be 'nil by mouth' for more than 6 hours following surgery.
- After minor surgery pre-meal and bedtime monitoring is adequate.
- Ask patients about their insulin requirements, as they may be the best judges of insulin dose adjustments.

### The patient with diabetes

Listed below are a few important pointers for treating a patient with diabetes:

- Diabetes is an individual disease and patients often have considerable knowledge and expertise in managing their diabetes.
- Patients dislike the lack of control over their diabetes treatment while they are in hospital, so always involve patients in the management of their diabetes.
- If the patient is knowledgeable, allow him/her to monitor and adjust the dose of insulin.
- Involve the diabetes team at an early stage if there are problems.

#### HbA1c

HbA1c is an indicator of glycaemic control over the previous 8 weeks. It is used by diabetologists to assess the success of treatment. The normal range may vary between laboratories but a reasonable assessment prior to surgery is:

HbA1c < 6.5%	Excellent glycaemic control
HbA1c 6.5–8.0%	Adequate control
HbA1c > 8.0%	Poor control

### How to manage diabetes during surgery

When considering diabetes management, the most important factor to consider is how long the patient will be fasting before surgery and how quickly he/she will be able to eat afterwards. Here, the term 'minor surgery' is used to describe an operation where the patient will be allowed to eat within a few hours and 'major surgery' refers to an operation where the patient will remain 'nil by mouth' for more than 6 hours following surgery. Dividing patients into three groups, depending on the mode of treatment, offers a simple and safe method of management.

#### Diet-only treatment

The patient fasts as normal anaesthetic instructions, and capillary glucose is monitored four times a day (before meals and before bed). People with diabetes treated by diet alone do not become hypoglycaemic. Monitoring diabetes ensures that good glycaemic control is maintained.

Intravenous dextrose must be avoided as a fluid replacement because blood glucose will rise. If capillary glucose remains higher than 10 mmol/l for more than 24 hours, the diabetic team should be involved to instigate more intensive treatment.

#### Oral hypoglycaemic agents

Beware of patients on long-acting hypoglycaemic drugs like glibenclamide; they may develop prolonged hypoglycaemia if fasted. Ideally, short-acting drops should be used pre-operatively, though this may not always be practicable. If patients remain on long-acting agents, vigilance must be maintained to detect and treat hypoglycaemia in the perioperative period.

**Minor surgery:** there are no restrictions to eating in the postoperative period. Omit tablets on the morning of surgery and give postoperatively with a light meal.

**Postoperative care:** record capillary glucose 4-hourly until the patients has recovered fully from anaesthesia.

**Major surgery:** there are restrictions to eating in the postoperative period (see list below).

**Postoperative care:** For patients treated with sulphonylurea tablets, consult the diabetic team regarding insulin requirement as they may need a phase of insulin in the immediate postoperative period.

#### AM list

Fast from midnight  
Omit tablets  
Start glucose insulin infusion at 07.00 \*\*

#### PM list

Early breakfast about 07.00  
Usual tablets at breakfast\*  
Fast from 08.00  
Start glucose insulin infusion at 11.00\*\*

\* Beware of patients on long-acting sulphonylureas. If they are on long-acting tablets, consider omitting tablets in the morning.

\*\* See later for glucose insulin infusions

#### Insulin treatment

**Minor surgery:** there are no eating restrictions in the postoperative period. If patient does not feel like a meal after the procedure, offer glucose drinks or snacks to avoid hypoglycaemia.

**AM list**

Fast from midnight  
Glucose drink at 06.00  
Delay insulin dose and  
breakfast until after  
procedure

**PM list**

Early breakfast about 07.00  
Fast from 08.00  
Half morning dose of insulin  
Glucose drink at 10.30  
Delay lunchtime insulin and  
lunch until after procedure

**Major surgery:** there are restrictions to eating in the immediate postoperative period.

**Postoperative care:** Always continue glucose infusions until meal time and restart insulin immediately. Consult diabetic team regarding return to subcutaneous regimen.

**AM list**

Fast from midnight  
No insulin in the  
morning  
Start glucose insulin  
infusion at 07.00

**PM list**

Early breakfast about 07.00  
Fast from 08.00  
Half usual insulin dose before  
early breakfast  
Start glucose insulin infusion  
at 11.00

**Glucose insulin infusions**

There are many methods of insulin delivery in patients undergoing surgery. Continuous intravenous insulin infusions generally attain better control and, subsequently, reduced incidence of wound infection.

**Intravenous dextrose with sliding-scale insulin pump**

Use 10% dextrose with KCl, 20 mmol/l and infuse intravenously 1 litre per 8–12 hours using a mechanical pump. Make up an insulin syringe pump infusion by adding 50 units of Actrapid insulin to 49 ml of normal saline in a 50 ml syringe. Using a syringe driver connect through a different IV cannula a sliding scale of insulin. Measure capillary glucose when commencing IV dextrose and insulin pump and hourly thereafter. The insulin infusion rate is adjusted according to the capillary glucose. If the sliding-scale insulin dosage fails to maintain adequate control (glucose ideally 4–7 mmol/l, adequate <10 mmol/l), alter the scale of insulin infusion to higher dose (see Figure 3).

The hourly glucose measurements required in this regimen constitute a high nursing workload. Also, care needs to be taken to ensure IV dextrose and IV insulin run simultaneously. If one cannula becomes blocked or one infusion runs out, the patient may become hypoglycaemic or hyperglycaemic with potentially serious consequences. Some centres infuse the insulin through the same IV cannula (piggy-back fashion) as the dextrose infusion but it is essential that both infusions are mechanically driven or a one-way valve is used. Without such safeguards there is potential for the syringe driver driving insulin to retrogradely fill the giving set with insulin if the cannula gets blocked. Once a new cannula has been sited and the infusions restarted, the patients may receive the large dose of insulin that has accumulated in the giving set. There are reports of patients becoming profoundly hypoglycaemic or even dying from this complication. Thus, many centres now use the GKI regimen instead (Figure 4).

**Example of intravenous insulin pump sliding scale used with 10% dextrose IV infusion**

Blood glucose (mmol/l)	Insulin per hour (units)	1st alteration of sliding scale
<3.0	0	0
3.1–4.0	0.5	0.5
4.1–6.0	1	1
6.1–9.0	2	3
9.1–11.0	3	5
11.1–13.0	4	7
13.1–15.0	5	8
15.1–20.0	6	10
>20.0	8	15

- Monitor capillary glucose hourly and adjust insulin dose accordingly
- Check urea and electrolytes daily
- Aim for glucose 4–7 mmol/l
- Adjust insulin scale if glucose > 10 mmol/l for > 12 hours

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**GKI (glucose potassium insulin) infusion**

GKI (glucose potassium insulin) infusion is a simpler and safer method to deliver glucose, potassium and insulin at an even rate. Twenty mmol (1.5 g) KCl and Actrapid insulin (dose per capillary glucose) are added to a 500 ml bag of 10% dextrose and administered over 6 hours using a mechanical pump (Figure 4). Check blood glucose every 3 hours and if the levels are too high or low, start a new bag with the correct insulin dose. With all the drugs mixed together in the same bag the consequences of the cannula blocking are not so dire.

**Example of GKI infusion regimen**

Blood glucose (mmol/l)	Actrapid insulin dose (units) in 10 % dextrose 500 ml	1st alteration in insulin dose
<2.9	0	0
3.0–5.9	5	5
6.0–9.9	10	10
10.0–13.9	15	20
14.0–19.9	20	30
>20.0	25	40

- Monitor capillary glucose 3-hourly and change infusion bag if insulin dose is not appropriate to glucose result
- Check urea and electrolytes daily
- Aim for glucose 4–7 mmol/l
- Adjust insulin scale if glucose > 10 mmol/l for >12 hours

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### Exceptions to GKI

- Poorly controlled diabetes – achieve control of glucose with an insulin pump or multiple subcutaneous injections of rapid-acting insulin and a basal intermediate insulin prior to commencing the GKI infusion.
- Hyperkalemia – omit the potassium in the infusion if serum  $K^+$  is  $> 5$  mmol/l.

### Limitations of GKI

- The regimen delivers only 2 litres of fluid over 24 hours so additional fluids should be prescribed to avoid dehydration.
- Hyponatremia may occur with prolonged infusions – avoid by giving IV normal saline (0.9% NaCl) infusions at the same time.
- Fluid balance in elderly and in heart failure requires care – if fluid restriction is needed, patients may need higher concentrations of dextrose to avoid fluid overload.

### Special surgical situations

- Heart surgery – glucose-containing solutions and inotropes necessitate increased insulin requirement.
- In pregnancy or during the post-delivery period, use of  $\beta_2$ -adrenoceptor agonists and corticosteroids may necessitate higher doses of insulin. There will be a sudden reduction of insulin requirement post-delivery.

### Return to normal diabetes treatment

Once patients with diabetes are eating and drinking they can be re-established on their normal treatment. Since insulin requirement is increased in the perioperative period the patient may require a higher dosage than on admission. Re-introduction of long-acting drugs will leave a window of poor glycaemic control while the drug(s) take effect. Thus, a short period of short-acting subcutaneous insulin may be necessary. The diabetes team will be able to advise on this.

### Diabetic control at home after discharge

Depending on the severity of surgery and the convalescent period required, it is likely that glycaemic control will be disturbed for a variable time after discharge. Most diabetic units have well-trained diabetes nurse specialists who will be able to advise patients about managing their treatment to optimize glucose levels. Usually, advice is given over the telephone. If the diabetes nurse specialist has not been involved during the patient's hospital stay, contact should be made prior to discharge so that appropriate follow-up can be organized. ♦

### FURTHER READING

- Husban D J, Thai A C, Alberti K G M M. Management of diabetes during surgery with glucose-insulin-potassium infusion. *Diabetic Med* 1986; **3**: 69–74.
- Van den Berghe G, Wouters P, Weekers F *et al*. Intensive insulin therapy in critically ill patients. *N Engl J Med* 2001; **345**: 1359–67.